Occupations, Cigarette Smoking, and Lung Cancer in the Epidemiological Follow-Up to the NHANES I and the California Occupational Mortality Study

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Abstract. *What jobs are associated with the highest and lowest levels of cigarette use and of lung cancer? Are there gender differences in these jobs? Two data sets—the Epidemiological Follow-up to the National Health and Nutrition Examination Survey (NHEFS) and the California Occupational Mortality Study (COMS) were analyzed to answer these questions. For females, the broad occupations ranking from highest to lowest cigarette use in the NHEFS was: transportation operators, managers, craft workers, service workers, operatives, laborers, technicians, administrative workers, farm owners and workers, sales workers, no occupation, and professionals. The corresponding ranking for males was: transportation operators, no occupation, laborers, craft workers, service workers, technicians, and professionals. The highest-ranking jobs in the COMS were waitresses, telephone operators, and cosmetologists for women, and water-transportation workers, roofers, foresters and loggers for men. Teachers were especially low on all four lists. This study could not determine whether employment within any occupation encouraged smoking or if smokers selected certain occupations.*

Research attention to associations between occupations on the one hand and cigarette use or lung cancer on the other has been limited. Some studies were concerned with aspects of jobs, such as whether the jobs were sedentary, physically active, stressful, and hazardous, as possible co-variates of cigarette use.[1–3] Other studies were descriptive and attempted to identify which occupations

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were most frequently populated by smokers,[4–9] or had the highest and lowest rates of lung cancer.[10,11] Research into other demographic characteristics, such as gender and race, however, has been extensive, as the references in Rogers[12] suggest.

This study is primarily descriptive, although some attempt will be made to explain why particular jobs may have many or few smokers, or be associated with high or low lung cancer rates. This is the first study to 1) use information from the Epidemiological Follow-up (NHEFS) to the National Health and Nutrition Examination Survey I or the California Occupational Mortality Study (COMS), 2) consider longest-held rather than current occupations (in the NHEFS), and 3) use Analysis of Covariance (AOC) techniques to simultaneously adjust for age, years of schooling, and attrition (in the use of NHEFS).

Subjects and Methods

NHEFS

A sample of persons who provided answers to a question pertaining to longest occupation held during life, and who also answered sex, age, education, and smoking questions in 1982–84, was drawn from the Epidemiological Follow-up to the NHANES I (NHEFS). The NHANES I is a multistage, stratified, probability sample of clusters of persons in land-based segments and is representative of the civilian non-institutionalized population then residing in the 48 states.[13] NHEFS is a follow-up survey conducted during 1982–84.[14] NHEFS investigators attempted to survey 14,407 subjects from the original NHANES I. Their success was remarkable; 13,383 were traced and accounted for. Of the 13,380 who were traced, 10,523 were reinterviewed, 2,022 were found to have died, and 8,389 were not interviewed. Thus, a total of 12,545 living and deceased subjects were available for analysis.

The study sample consisted of 6,163 women and 3,789 men. The sample was smaller than the 12,545 available in the NHEFS because it was required that subjects 1) be alive in 1982–84, 2) provide answers to the smoking question, and 3) provide answers to a 1982–84 question pertaining to usual or longest-held occupa-

tion, as well as questions pertaining to sex, age and education. The NHEFS usual occupation question was the following: "What kind of work have you done for the longest period of time? What was your occupation or complete job title? For example, carpenter, secretary, electrical engineer." Ages of subjects ranged between and included 30 to 86. Unlike earlier studies, no attempt was made here to restrict attention to those less than 66 years old, i.e., those not retired.

The dependent variable was created from responses to the following questions: 1) "About how many cigarettes a day do you now smoke?" 2) "Did you stop smoking cigarettes in the past year?" 3) "During all the years when you were smoking, about how many cigarettes a day did you usually smoke?" If subjects were current smokers or had not smoked or quit during the past year, only information from question 1 was used to construct the dependent variable: daily cigarette use during the past year. If they answered "yes" to question 2, information from question 3 was used to construct the variable for daily cigarette use during the last year. Thus, recent quitters were included in the smoking category. The dependent variable was either 1) the number of cigarettes smoked daily by current smokers or by persons who had not smoked during the past year, or 2) the average number smoked daily by persons before they quit during the past year. The dependent variable was recorded in integers ranging from 0 to 100. Means and standard deviations for women and men were the following: 4.42, 9.74 (women), and 5.14, 11.29 (men).

The 1982–84 NHEFS used the 1980 US Census Occupation Codes. The Census codes contain roughly 500 specific jobs and 12 broad categories.[15] Analyses were conducted on both the broad categories and the specific jobs. Not all 500 specific jobs were considered, however. Attention was restricted to jobs with at least 20 members; including jobs with fewer than 20 members would have invited numerous questionable rankings. One person with very high cigarette use could dramatically alter the rank of an occupation with 10 or fewer respondents. The minimum of 20

incumbents restriction resulted in 64 specific (three-digit) female jobs and 61 specific (three-digit) male jobs.

Several methods were used to rank the occupations within the NHEFS. The first involved a simple calculation of the mean cigarette use within each of the 12 categories, and 64 and 61 specific jobs. Men and women were separated because of the well-known differences in cigarette use between the sexes.[6,12,16] A simple average within occupations, however, does not account for well-known covariates, such as age, race, and education level.

The second method involved applications of Tobit and Probit models. In the first model, Tobit regression was applied. The dependent variable was the number of cigarettes smoked. Because more than half of the sample did not smoke, many zeros were present for the dependent variable. The Tobit model was designed to estimate relationships when the dependent variable is truncated, as in this case at 0. The independent variables were age (but not age-squared), black race, years of schooling, an attrition instrumental variable, and binary variables representing the occupations. Eleven (11) binary variables were included in the analysis of the broad categories; 63 binary variables were included in the specific occupations model for women, and 60 binary variables in the male-specific occupations model. One binary occupation variable had to be eliminated to break the perfect co-linearity.[17] The Tobit regression model described here, which includes binary (dummy) occupation variables, is similar to an AOC model.[18,19] Both the Tobit and AOC models allow for the calculation of mean cigarette use, controlling for the associations of age, race, years of schooling, and attrition.

Between baseline (1971–1975) and follow-up (1982–1984), approximately 14% of the adults had died. To minimize the bias of attrition due to death, an econometric sample selection technique was applied.[20–23] The technique involves the creation of an instrumental variable that attempts to measure the unobserved probability of dying over the 10 to 14 years of follow-up. In the simplest version of the technique, a Probit regression was run on all of the living and deceased subjects in the follow-up sample.

The Probit regression was used to explain mortality. The dependent variable was binary and indicated whether the subject died (= 1) or lived (= 0). This binary variable was then regressed on covariates measured at baseline (1971–1975), which were thought to influence the probability of dying before the follow-up (1982–1984). The baseline covariates included age, age-squared, black race, married spouse present, years of schooling, and dummy variables for 11 of the 12 broad categories. Professionals were eliminated to break the perfect co-linearity. The predicted values for the binary probability variable were then placed into a hazard rate or inverse Mills ratio. Values of the inverse Mills ratio then became the observations for the instrumental variable. Each subject who lived throughout the follow-up was assigned a value for the inverse Mills ratio that indirectly measured the probability of dying over the 10 to 14 years that would have applied at baseline. For example, 70-year-olds were assigned a higher probability than 30-year-olds. The inverse Mills values were then treated as an additional covariate in the least squares regression that attempts to explain the number of cigarettes smoked. The cigarette regression contained only the living subjects in the NHEFS.

Attrition bias was similarly accounted for in the NHEFS in a study on occupations and disability.[24]

The NHANES I and NHEFS are geographic cluster samples. Variances of errors across clusters may be different than those across respondents.[25–27] Moulton[28] and Dickens[29] have formulated random-effects models that account for these different variances. The Moulton and Dickens random-effects techniques account for the cluster correlation by estimating a model with two error terms: one for the variation in geographic clusters, and another for the usual variation across subjects and clusters. The Moulton and Dickens techniques are similar to the random effects models that are popular in analyses of panel data.[22] The resulting estimated coefficients, after applying the Moulton-Dickens techniques, are more efficient than would be obtained with a Tobit regression that ignored the geographic cluster problem.

This study uses Dickens's technique. First, sample means of

the smoking variable and the covariates—age, black race, schooling, and the attrition inverse Mills ratio—were calculated within each of 64 geographic clusters. Next, the 64 sample means for smoking were regressed on the sample means for the covariates. Residuals were obtained. Squared residuals were then regressed on $1/N_i$ and a constant, where N_i represents the number of people within each of the 64 geographic clusters. Dickens shows that the estimated intercept is a consistent estimate of the variance associated with the geographic clusters, and the estimated slope is a consistent estimate of the variance associated with the usual error. The second estimated variance was then divided by N_i, and added to the estimated error for the clusters. The square root of this sum was then divided into each observation in the original sample. The square root of the sums is called the weights. The second Tobit regression was run on the sample weighted by the two estimated variances from Dickens's technique. Predicted values from the Tobit were then multiplied by the square root of the same sums (the weights) to provide estimates of cigarette use (not cigarettes divided by the weights).

All models were estimated with LIMDEP software.[30]

COMS

Investigators from the Health Demographics Section of the California Department of Health Services gathered information from 173,438 death certificates for 1979, 1980, and 1981. The data were organized into the California Occupational Mortality Study (COMS). To be included in the COMS, decedents must have been 16 to 64 years old, have detailed information on cause of death, and most importantly, a usual occupation. Occupations were coded in 1980 US Census classifications and the causes of death were coded according to the International Classification of Diseases, Ninth Revision.[31] Denominators were gathered for the working population by age, sex, race, and occupation available in the US Bureau of the Census from the 10% sample of the 1980 California Census.

Age-adjusted Standardized Mortality Ratios (SMR) and stan-

TABLE I
AGE AND EDUCATION LEVEL FOR WOMEN AND MEN WITHIN BROAD OCCUPATION CATEGORIES

	Mean and (Standard Error)			
	Women		Men	
	Age	Education	Age	Education
1. Professionals	45.1 (1.0)	13.2 (.2)	46.2 (1.2)	14.3 (.5)
2. Managers	43.4 (1.2)	12.5 (.3)	45.2 (1.0)	13.7 (.3)
3. Administrative workers	41.9 (.5)	12.2 (.1)	47.5 (1.3)	12.0 (.4)
4. Sales workers	46.0 (.9)	11.8 (.3)	46.8 (1.2)	12.9 (.3)
5. Technicians	40.9 (1.9)	12.2 (.5)	40.9 (2.2)	13.1 (.7)
6. Crafts vendors	46.5 (1.7)	10.3 (.5)	48.9 (.7)	10.4 (.2)
7. Operatives	46.7 (.8)	9.7 (.2)	47.2 (1.0)	9.7 (.3)
8. Transportation operators	35.2 (3.4)	11.6 (.9)	46.2 (1.2)	9.8 (.4)
9. Service occupations	45.8 (.6)	9.9 (.2)	48.5 (1.4)	10.2 (.4)
10. Handlers, cleaners, helpers, laborers	46.6 (1.9)	9.7 (.5)	50.2 (1.7)	8.1 (.5)
11. Farming, forestry fishing	49.2 (2.3)	8.9 (.6)	56.1 (1.0)	8.4 (.3)
12. No occupation, unemployed, homemaker	51.8 (.7)	8.9 (.2)	52.0 (3.0)	7.7 (.9)

dard errors were calculated in the usual way. Age categories were split into 16–44, 45–54, 55–59, and 60–64. The raw death rate for all white women or white men in the COMS in all occupations due to lung cancer was expressed on an annual basis. Expected deaths within a given occupation involved multiplying the population employed in the occupation by the death rate for all white women or men within a given age. Observed deaths were taken directly from the death certificates.

A complete description of the COMS and SMR and confidence interval calculations is available.[32] A brief description also is available.[33] This study merely uses the SMRs and confidence intervals already published by the State of California.[32] The COMS published report 1) provided SMRs for a variety of diseases, not just lung cancer; 2) did not provide an analysis of why particular jobs might be high or low in lung cancer deaths; 3) did not link their results to the literature; 4) did not rank jobs from high to low SMRS; and 5) has not received the attention it deserves in the research literature. It appears that only a handful of reports using the COMS data have appeared in the medical or epidemiological literature.[33–35] None of these three reports addressed lung cancer deaths.

TABLE II
BROAD LONGEST-HELD OCCUPATION RESULTS FOR WOMEN, CONTROLLING FOR AGE, BLACK RACE, YEARS OF SCHOOLING, ATTRITION, AND CLUSTER CORRELATIONS

Rank	Occupation	Sample Size	Number of Cigarettes per Day	95% Confidence Interval
1.	Transportation operatives	37	7.71	(8.44–6.98)
2.	Managers	288	6.17	(6.82–5.52)
3.	Craftsworkers	162	5.17	(5.73–4.61)
4.	Service workers	1093	5.06	(5.64–4.48)
5.	Operatives	712	5.02	(5.41–4.63)
6.	Laborers	119	4.58	(4.93–4.23)
7.	Technicians	130	4.46	(5.09–3.83)
8.	Administrative workers	1541	4.26	(4.68–3.84)
9.	Farm owners and workers	88	4.17	(4.49–3.85)
10.	Sales workers	481	4.04	(4.43–3.65)
11.	No occupation, unemployed homemaker	762	3.75	(4.07–3.43)
12.	Professionals	750	3.02	(3.42–2.62)

n = 6163.

TABLE III
BROAD LONGEST-HELD OCCUPATION RESULTS FOR MEN, CONTROLLING FOR AGE, BLACK RACE, YEARS OF SCHOOLING, ATTRITION, AND CLUSTER CORRELATIONS

Rank	Occupation	Sample Size	Number of Cigarettes per Day	95% Confidence Interval
1.	Transportation operatives	291	7.67	(8.10–724)
2.	No occupation, unemployed disabled	45	6.29	(6.94–5.69)
3.	Laborers	149	6.16	(6.81–5.51)
4.	Craftsworkers	874	5.99	(6.39–5.59)
5.	Service workers	209	5.77	(6.23–5.31)
6.	Sales workers	289	5.71	(6.18–5.24)
7.	Operatives	367	5.51	(5.99–5.03)
8.	Administrative workers	249	5.27	(5.84–4.70)
9.	Managers	422	4.23	(5.08–3.38)
10.	Farm owners and workers	381	4.15	(4.42–3.88)
11.	Technicians	88	3.22	(4.10–2.54)
12.	Professionals	425	2.63	(3.24–2.02)

n = 3789.

NHEFS Results

Table I presents results on the age and education level within broad occupational groups. White-collar workers tend to have more education than blue-collar workers.

Tables II and III present Tobit regression results controlling for

TABLE IV
SPECIFIC LONGEST-HELD OCCUPATION RANKINGS FOR WOMEN, CONTROLLING FOR AGE, BLACK RACE, YEARS OF SCHOOLING, ATTRITION, AND CLUSTER CORRELATIONS

Rank	1980 Census Occupation Category	1980 Census Code	Sample Size	Number of Cigarettes per Day
1.	Street, door-to-door sales workers	277	20	8.641
2.	Waitresses	435	130	8.571
3.	Graders and sorters, except agricultural	799	26	7.289
4.	Managers and administrators (n.e.c.)	19	121	7.225
5.	Bus drivers	808	21	6.989
6.	Supervisors, general office	303	29	6.773
7.	Receptionists	319	41	6.506
8.	Assemblers	785	78	6.263
9.	Social workers	174	36	6.250
10.	Health aides, except nursing	446	32	6.107
11.	Data-entry clerks	385	36	6.042
12.	Payroll and timekeeping clerks	338	22	5.953
13.	Supervisors, food preparation and service occupation	433	30	5.496
14.	Licensed practical nurses	207	66	5.321
15.	Designers	185	21	5.284
16.	Typists, information clerks	315	39	5.259
17.	Laborers, except construction	889	28	5.038
18.	Pressing machine operators	747	41	5.031
19.	Accountants and auditors	23	31	5.023
20.	Nursing aides, orderlies, attendants	447	130	4.904
21.	Miscellaneous machine operators (n.e.c.)	777	41	4.828
22.	Hand packers and packagers	888	64	4.802
23.	Supervisors, production occupations	633	28	4.741
24.	Hairdressers and cosmetologists	458	72	4.732
25.	Sales workers, apparel	264	31	4.670
26.	Cooks, except short order	436	82	4.573
27.	Packaging and filling machine operators	754	27	4.563
28.	Knitting, looping, taping, and weaving machine operators	739	24	4.409
29.	Janitors and cleaners	453	39	4.395
30.	Winding and twisting machine	738	31	4.293
31.	Supervisors and proprietors, sales occupations	243	84	4.287
32.	Bank tellers	383	31	4.215
33.	Bookkeepers, accounting, and auditing clerks	337	154	4.186
34.	Sales workers, other commodities	274	72	4.147
35.	Textile sewing machine operators	744	150	3.963
36.	Farmers, except horticultural	473	34	3.962
37.	Secretaries	313	418	3.908
38.	General office clerks	379	98	3.878
39.	No occupation	997	762	3.753
40.	Kitchen workers, food preparation	439	37	3.743
41.	Production inspectors, checkers, examiners	796	44	3.708
42.	Maids	449	55	3.679
43.	Housekeepers and butlers	405	32	3.655

TABLE IV
CONTINUED

Rank	1980 Census Occupation Category	1980 Census Code	Sample Size	Number of Cigarettes per Day
44.	Miscellaneous food preparation occupations	444	38	3.582
45.	Telephone operators (n.e.c.)	348	60	3.521
46.	Registered nurses	95	122	3.511
47.	Real estate sales occupations	254	22	3.349
48.	Private houesehold cleaners and servants	407	136	3.322
49.	Farm workers	479	51	3.295
50.	Child care workers, private household	406	26	3.065
51.	Teachers' aides	387	42	3.046
52.	Dressmakers	666	41	2.878
53.	Cashiers	276	93	2.834
54.	Machine operators, not specified	779	30	2.707
55.	Stenographers	314	24	2.700
56.	Laundering and dry cleaning machine operators	748	29	2.676
57.	Sales counter clerks	275	42	2.633
58.	Teachers (n.e.c.)	159	41	2.633
59.	Teachers, elementary school	156	171	2.540
60.	Teachers, secondary school	157	60	2.530
61.	Order clerks	327	28	2.295
62.	File clerks	335	24	1.550
63.	Child care workers, except private household	468	21	0.844
64.	Teachers, prekindergarten and kindergarten	155	33	0.749

n.e.c., not elsewhere classified.

age, black race, years of schooling, attrition, and geographic cluster correlations for women and men in the broad occupation categories. Predicted values for the dependent variable, cigarettes smoked, were multiplied by the square root of the sum of the two estimated variances derived from the Dickens[29] technique. Mean values in the tables, therefore, can be interpreted as a number of cigarettes smoked. The first column presents the occupation category; the second, the sample size; the third, the rank; and the fourth and fifth present the mean and 95% confidence intervals for mean cigarette use.

The ranking for women from highest to lowest cigarette use was as follows: transportation operatives, managers, craftsworkers, service workers, operatives, laborers, technicians, administrative personnel, farm owners and workers, sales workers, no occupation, and professionals. The ranking for men in Table III was: transportation operatives, no occupation, laborers, craftsworkers,

TABLE V
SPECIFIC LONGEST-HELD OCCUPATION RANKINGS FOR MEN, CONTROLLING FOR AGE, BLACK RACE, YEARS OF SCHOOLING, ATTRITION, AND CLUSTER CORRELATIONS

Rank	1980 Census Occupation Category	1980 Census Code	Sample Size	Number of Cigarettes per Day
1.	Supervisors, production occupations	633	83	9.274
2.	Butchers and meat cutters	686	30	8.346
3.	Automobile mechanics	505	58	7.894
4.	Truck drivers, light	805	27	7.701
5.	Truck drivers, heavy	804	137	7.629
6.	Sales workers, other commodities	274	25	7.522
7.	Supervisors, mechanics and repairers	503	28	7.205
8.	Police and detectives, public service	418	26	7.118
9.	Sawing machine operators	727	23	6.911
10.	Supervisors (n.e.c.)	558	75	6.830
11.	No occupation	997	45	6.290
12.	Machinery maintenance occupations	519	25	6.199
13.	Insurance sales occupations	253	28	6.192
14.	Street and door-to-door sales workers	277	22	5.992
15.	Mail carriers, postal service	355	23	5.930
16.	Carpenters	567	117	5.897
17.	Miscellaneous machine operators (n.e.c.)	777	48	5.863
18.	Construction laborers	869	57	5.692
19.	Machine operators, not specified	779	45	5.678
20.	Production inspectors, checkers, and examiners	796	23	5.610
21.	Welders and cutters	783	70	5.566
22.	Stock and inventory clerks	365	26	5.510
23.	Mining machine operators	616	49	5.508
24.	Bus drivers	808	29	5.392
25.	Brickmasons, stonemasons	563	23	5.382
26.	Managers and administrators (n.e.c.)	19	251	5.263
27.	Driver-sales workers	806	25	5.204
28.	Postal clerks, except mail carriers	354	37	4.868
29.	Supervisors and proprietors, sales occupations	243	152	4.801
30.	Administrators and officials, public administration	5	26	4.781
31.	Industrial truck and tractor equipment operators	856	36	4.777
32.	Accountants and auditors	23	33	4.693
33.	Plumbers, pipefitters, and steamfitters	585	47	4.567
34.	Miscellaneous textile machine operators	749	23	4.510
35.	Sales representatives, mining, manufacturing, and wholesale	259	34	4.404
36.	Electricians	575	52	4.342
37.	Janitors and cleaners	453	78	4.337
38.	Painters, construction and maintenance	579	29	4.314
39.	Machinists	637	29	4.216
40.	Laborers, except construction	889	87	4.173
41.	Administrators, education and related fields	14	28	4.101
42.	Cooks, except short order	436	24	3.797
43.	Freight, stock, and material handlers (n.e.c.)	883	27	3.680
44.	Electrical and electronic engineers	55	39	3.440

TABLE V
CONTINUED

Rank	1980 Census Occupation Category	1980 Census Code	Sample Size	Number of Cigarettes per Day
45.	Bookkeeping, accounting, and auditing clerks	337	28	3.285
46.	Farmers, except horticultural	473	330	3.274
47.	Barbers	457	24	3.232
48.	Assemblers	785	28	3.205
49.	Farm workers	479	99	3.168
50.	Bus, truck, and stationary engine mechanics	507	22	3.103
51.	Teachers, elementary school	156	20	3.068
52.	Mechanical engineers	57	27	3.067
53.	Industrial machinery repairers	518	26	2.875
54.	Managers, marketing, advertising public relations	13	24	2.658
55.	Tool and die makers	634	27	2.651
56.	Lawyers	178	30	2.603
57.	Electrical and electronic technicians	213	25	2.587
58.	Clergy	176	32	2.284
59.	Traffic, shipping, and receiving clerks	364	25	2.216
60.	Civil engineers	53	27	1.542
61.	Teachers, secondary school	157	34	0.721

n.e.c., not elsewhere classified.

service workers, sales workers, operatives, administrative workers, managers, farm owners and workers, technicians, and professionals.

Both Tables II and III included covariates for age, black race, schooling, and attrition. The results on age as a covariate, available from the author, suggested that cigarette use decreased with advancing age for both sexes. Results suggested that the coefficient on the black-race variable was not significantly different from zero. The insignificance of black race could be caused by the many occupation variables also in the regressions. Estimated coefficients on education was statistically insignificant in the female Tobit, but statistically significant and negative in the male Tobit regression. The coefficient on the instrumental variable reflecting attrition was statistically significant and negative for men and women, suggesting that the tendency to remain in the sample (not die) over the 10 to 14 years at follow-up was negatively associated with cigarette use. The results for the attrition regressions explaining

mortality over the follow-up are also omitted in the interest of brevity.

Tables IV and V present rankings for women and men in specific (three-digit) jobs. High-cigarette-use jobs for women included door-to-door sales workers, waitresses, graders and sorters, managers not elsewhere classified, bus drivers, general office supervisors, receptionists, assemblers, and social workers. Low-cigarette-use jobs for women included kindergarten teachers, child care workers, file clerks, order clerks, teachers, sales counter clerks, dry cleaning operators, and stenographers. High-cigarette-use jobs for men included production supervisors, butchers and meat cutters, automobile mechanics, light- and heavy-truck drivers, sales workers not elsewhere classified, supervisors for mechanics, and police officers. Low-cigarette-use jobs for men included secondary school teachers, civil engineers, shipping clerks, clergy, electronic technicians, lawyers, tool and die makers, advertising managers, machinery reporters, mechanical engineers, and elementary school teachers.

COMS Results

Tables VI and VII present results from the COMS on ranking occupations by lung cancer. The format is similar to that in Tables II through V. Researchers for the State of California created their own job groups, but carefully indicated the corresponding 1980 US Census codes. These groups and codes appear in column 2. The group definition appears in column 3 under "Category." The SMRs and confidence intervals are in columns 4 and 5.

Numbers in column 6 are unique to Tables VI and VII. Column 6 presents the rankings for the same occupation or group from the corresponding cigarette use in Tables IV and V. For example, the number 2 in the first row, last column of Table VI indicates that waitresses were ranked in the second position in cigarette use in Table IV. Blanks in column 6 indicate that occupations or groups could not be matched across tables. Numbers in columns 6 and 1 can be used to compare the rankings by cigarette use and lung

TABLE VI
WHITE WOMEN DYING DUE TO LUNG CANCER, ADJUSTED FOR AGE

Rank	1980 Occupation Code	Category	SMR	95% C.I.	Rank in Table IV
1.	435	Waitresses	368	427–309	2
2.	348–353	Telephone operators	191	249–134	45
3.	457–458	Cosmetologists, barbers	188	243–133	24
4.	213–225	Technicians	172	230–115	—
5.	243	Proprietors, sales supervisors	145	184–105	31
6.	666–674	Dress makers	139	204–73	—
7.	207, 445–447	Health aides, orderlies	138	164–112	14
8.	023–037	Management related jobs	133	158–107	19
9.	226, 803–859	Transportation/equipment operators	126	188–64	5
10.	703–737	Misc. production workers	124	144–104	—
11.	084–089	Other health professionals	119	159–79	—
12.	003–019	Managers	118	134–103	4
13.	863–889	Laborer & helper, others	109	141–77	17
14.	337	Bookkeepers	108	125–90	33
15.	185, 188–189	Artists, photographers	106	155–57	—
16.	313–315	Secretaries, typists	105	117–93	16
17.	403, 747–748	Launderers, dry cleaners	102	162–42	18
18.	436–437	Cooks	103	136–69	26
19.	043–083	Other professional specialities	101	123–79	Too broad
20.	503–659	Skilled crafts workers	094	117–70	Too broad
21.	404, 433–434	Other food service workers	092	120–64	13
22.	253–285	Sales workers	081	92–70	Too broad
23.	205, 234	Other clerical workers	080	89–71	—
24.	738–745	Other textile workers	078	112–44	28
25.	095	Registered nurses	061	79–43	46
26.	455, 473–499	Agricultural workers	053	79–27	36
27.	113–159	Teachers	049	61–38	58
28.	405, 407	Housekeepers, janitors	045	60–31	43
29.	406, 413–427	Misc. personal services	041	57–26	Too broad

cancer. Rank correlation coefficients between columns 6 and 1 were statistically significant at better than the 0.001 level in Table VI, and at better than the 0.01 level in Table VII. The statistically significant coefficients suggest that the matched occupations display similar rankings in the paired tables. This is strong evidence that, given that the data are from different sources, the rankings are credible. We would not expect perfect correlations, however, because smoking is only one cause of lung cancer.

For women in Table VI, the following jobs had the highest SMRs: waitresses, telephone operators, cosmetologists, and tech-

TABLE VII
WHITE MEN DYING DUE TO LUNG CANCER, ADJUSTED FOR AGE

Rank	1980 Occupation Code	Category	SMR	95% C.I.	Rank in Table V
1.	828–834	Water-transportation workers	368	483–252	—
2.	595	Roofers	329	453–252	—
3.	494–496	Foresters, loggers	289	419–159	—
4.	694–699	Plant & systems operators	258	315–201	—
5.	844	Operating engineers	249	311–188	—
6.	434	Bartenders	244	301–186	—
7.	598, 613–617	Miners & drillers	243	326–160	23
8.	653, 654	Sheet metal workers	199	261–137	—
9.	556, 579 –584	Painters, plasterers	199	231–167	38
10.	804	Drivers (truck)	183	204–162	5
11.	783–784	Welders	173	211–134	21
12.	864, 873	Helpers & laborers	167	193–141	—
13.	634–652	Metal workers	164	183–145	—
14.	553, 563–564	Brick & stone masons	163	189–138	25
15.	565–566	Other construction workers	163	187–139	18
16.	556	Construction supervisors, misc.	163	189–139	10
17.	189	Photographers	162	241–83	—
18.	554, 567–569	Carpenters	161	184–37	16
19.	557, 585–587	Plumbers, duct workers	153	186–121	33
20.	413, 416–417	Firefighters	150	204–95	—
21.	433, 438–444	Other food service workers	150	137–73	—
22.	555, 575–577	Electricians	148	177–120	36
23.	734 –737	Printing/photo processing	145	181–109	—
24.	243	Proprietors, sales supervisors	145	164–127	29
25.	353	Mail carriers	144	186–103	15
26.	445–447	Health aides	139	209–69	—
27.	686–688	Food product workers	135	169–101	—
28.	505–507	Auto/truck mechanics	131	154–108	50
29.	508, 515	Aircraft mechanics	129	170–87	—
30.	483, 487	Fishers, hunters, animal caretakers	128	197–58	—
31.	808	Drivers - bus	124	169–79	24
32.	403, 747–748	Launderers/dry cleaners	123	189–56	—
33.	803, 805–806	Drivers (other)	122	147–97	27
34.	514	Auto body workers	120	174–66	—
35.	414–415	Police, guards	117	137–96	8
36.	186–187	Performing artists	113	148–79	—
37.	253–259	Retail sales workers	112	127–98	35
38.	875–883	Freight & material movers	111	141–81	43
39.	226, 813–826	Other transportation workers	110	146–73	—
40.	503, 509	Other mechanics, repairers	108	122–93	—
41.	689–693	Inspectors, testers	106	131–81	—
42.	404, 436–437	Cooks	104	141–68	42
43.	675–684	Misc. production workers	100	113–86	—
44.	406, 459–469	Misc. service workers	096	136–55	—
45.	064–083	Scientists	094	120–69	—
46.	633, 863	Factory/misc. labor supervisors	092	105–79	—
47.	885	Garage & service station attendants	091	140–41	—
48.	656–659	Wood workers	088	126–49	—

TABLE VII
CONTINUED

Rank	1980 Occupation Code	Category	SMR	95% C.I.	Rank in Table V
49.	213–225	Technicians	085	99–70	—
50.	477–479	Farm workers	084	99–68	—
51.	043–063	Architects & engineers	084	94–74	—
52.	184, 188	Artists	084	114–55	—
53.	527–529	Telephone/line installers/repairers	083	118–49	—
54.	405, 407, 448–453	Janitors	082	94–70	37
55.	023–037	Management related jobs	079	89–68	—
56.	523, 533	Electronic/electrical repairers	075	109–41	—
57.	666–674	Textile workers	075	106–45	—
58.	456–458	Barbers, cosmetologists	073	106–40	47
59.	473–476	Farmers, farm managers	072	89–54	46
60.	455, 485–486	Gardeners, other agricultural workers	071	89–52	—
61.	303–154	Clerical workers	070	78–62	45
62.	003–018	Managers	070	75–65	41
63.	253	Business sales workers	064	72–57	13
64.	834, 845–859	Heavy equipment operators	062	81–43	31
65.	095–106	Other health professionals	060	88–32	—
66.	163–184	Other professional specialists	052	62–421	—
67.	113–159	Teachers	038	47–30	61
68.	084–089	Physicians & dentists	025	34–15	—

nicians. Those with the lowest risk for lung cancer included registered nurses, teachers, and housekeepers.

For men in Table VII, the following jobs had the highest SMRs: water-transportation workers, roofers, loggers, plant operators, operating engineers, and bartenders. Those with the lowest SMRs included teachers, doctors, and dentists.

Discussion

The goals of this study were to provide preliminary rankings of occupations for women and men based on the average number of cigarettes smoked by incumbents, and lung cancer rates. Tables II through VII provide these rankings. There are three unique features of this study using the NHEFS data. First, the measure of occupations pertains to the job the respondent had for the "longest period of time," not necessarily the current job. The longest-job question in the NHEFS elicited responses from all people, whether now working or retired or homemakers. Second, the

Tobit and Probit regression techniques removed the linear association of cigarette use on the one hand and age, black race, schooling, and attrition on the other, as well as adjusted for geographic cluster correlations. Third, the samples were large: 6,163 women and 3,789 men. Unique features for the COMS data include 1) "usual" occupation listed on the death certificate, and 2) SMRs were age-adjusted.

Criticisms and Rebuttals

A number of criticisms can be noted. First, people will change jobs over their lifetimes, so that people's stated longest-held or usual occupation may not reflect their true possible occupational exposures and attachments over their lifetimes. There are answers to this criticism, however. A surprisingly high number of people stay in one occupation for many years. In 1987, roughly 50% of men and women, age 55 to 59, had been in the same occupation for 20 or more years.[36] One alternative measure would rank jobs based on the cigarette use or lung cancer of current job holders. But current job holders would not fairly represent occupational influences. Many people "job hop." Over 20% of the American workforce have been employed at their current job less than 2 years.[36] A second alternative measure available in the NHEFS would rank jobs in 1971–1975 based on the cigarette use in 1982–1984. But this measure also suffers since many people will have changed jobs between 1971 and 1984. What is needed is a longitudinal data set covering at least 10 years that indicates persons, jobs, cigarette use, and lung cancer deaths in every year. We are unaware of any national probability sample with these characteristics.

A second criticism, applying only to the NHEFS data, involves mortality. Roughly 2,022 of 14,407 in the original NHANES I respondents died over the 10-year follow-up. It could be that the occupations which encourage or reinforce the smoking habit also kill a disproportionate number of workers due to accidents, injuries, cancer, and heart disease. This criticism suggests that the NHEFS would result in a biased sample in favor of an over-

representation of jobs that do *not* encourage smoking or are in any way associated with smoking.

There are answers to this criticism, too. The criticism would imply that some important occupations would not have enough respondents in 1982–1984 to be included in Tables II through V. But the broad occupations in Tables II and III include all possible broad categories, and specific (3-digit) occupations in Tables IV and V account for over 70% of all employees in Tables II and III. Moreover, 31 of the top 40 jobs with the highest job-related mortality rates are included in Tables IV and V.[37] Finally, the instrumental variable is designed to remove the bias associated with attrition due to death.

A third criticism of the NHEFS would suggest that basing estimates on only 20 members within an occupation may be invalid. One or two extreme scores could pull the occupation to the top of the list. This criticism also has rebuttals. 1) An alternative is to limit the occupation to, say, 40 members. But this higher limit would result in close to half of the occupations in Tables IV and V being ignored. 2) It is unlikely that the extreme values would affect many of the occupations. Extreme values are rare. Given that the larger occupations account for the greater majority of the samples for women and men, extreme values are much more likely to be included in an occupation with many than with few members. In any case, Tables II and III, which rank the 12 broad categories, do not suffer from this criticism.

A final criticism of the NHEFS involves the definition of the smoking variable. The NHEFS has information on past smoking. As mentioned, persons who quit within the past years were included as smokers. The smoking variable definition used here was consistent with the earlier literature.[1–8] But information on age when smoking began, whether one ever smoked 100 cigarettes, length of time smoked, and attempts to quit, all of which are available in the NHEFS, was ignored. The reason for limiting the analysis of this study was parsimony. Future researchers may want to analyze quit behavior including the number of cigarettes consumed before quitting, the age of quitting, and so on.

The NHEFS portion of this study would be more convincing if 20 years of longitudinal data on, say, 20,000 employees were available. Unfortunately, they are not. Future researchers with better data may nevertheless be interested in comparing their results with these preliminary findings.

A number of limitations of the COMS data also are worth noting. First, the data were drawn from only one state during 1979 to 1981. Caution should be exercised when attempting to generalize these findings to other states or the United States as a whole for the 1990s. Nevertheless, in partial reply to this criticism, it should be noted that 1) California has the largest population of any of the states; 2) the most widely cited lung cancer studies rely on data from the 1950s, 1960s, and 1970s;[10,11] and 3) the number of death certificates included in the COMS study was large—173,438.

Second, there may have been errors in coding the cause of death, occupation, or industry. There also are partial answers to this criticism. The COMS investigators noted that a 1979 study of 9,724 Vermont death certificates found a high concordance (72%) between cause of death on death certificates and hospital records.[38] A study by Engle et al.[39] found an 89% concordance rate.

Accurate occupation information may be more problematic than cause of death information because record-keepers are more likely better trained in the medical than social sciences. The COMS investigators, nevertheless, cite five highly regarded studies suggesting that agreement between a variety of sources ranged between 50% to 80%.[38–42] The sources included hospital, company, union, state employment, insurance office records, interviews with next of kin, and interviews with decedents before death.

But there is an additional problem with the occupation data. Even when accurately recorded, only a single occupation was recorded, yet most people work at more than one job and more than one industry during their lives.[43] However, death certificates in California during 1979 to 1981 clearly specified "usual" or "primary" occupation. Whereas exposure to job-related accidents

or injuries can occur quickly, lung cancer requires a long gestation period. The job-hopping problem may be more serious for accidents and injuries than lung cancer. To the extent that lung cancer is causally related to any occupation or industry, it is more likely that the job would have been the "usual" or "primary" job than a job the worker had as a youth or just recently took.

Another limitation concerns denominator data. The denominator data were drawn from the US Census of California during 1980. They are undoubtedly highly accurate in describing the characteristics of employed people in 1980. The problem occurs with the decedents who may have been disabled or chronically unemployed years before 1980. Levels of employment within occupations and industries fluctuate from year to year. Again, there are answers to this limitation. This criticism is serious for jobs with few members, but rapid percentage decreases or increases in employment within *large* occupations and industries are rare.[43] The COMS investigators aggregated 502 three-digit Census-specific occupations into 68 broad male occupations and 29 broad female occupations.

A final limitation of the COMS data is that they ignore the unemployed. Long periods of unemployment may be the cause of considerable stress and smoking.[44]

Interpretation of Results

Setting aside the results for women managers in Table II, Tables II and III suggest that employees in blue-collar jobs smoke more than employees in white-collar jobs. Moreover, Tables II and III further suggest that the highest paid white-collar jobs, professionals, have the lowest cigarette use. The blue-collar and white-collar contrast is especially pronounced among men in Table III. Evidence for the blue-collar/white-collar difference is also available in Tables V and VII. For men, butchers, mechanics, truck drivers, transportation workers, roofers, loggers, bartenders, miners, and sheet metal workers appear close to the top. Teachers, engineers, clergy, lawyers, doctors, dentists, health professionals,

and managers appear at the bottom of the list. The difference is weaker among women, however, in Tables IV and VI.

These results are all the more remarkable given that years of schooling and black race were removed as confounding variables in the analysis of the NHEFS. Schooling is strongly and positively associated with employment in white-collar jobs, as well as being negatively correlated with smoking.[7,43] The opposite is true for black-race variables.[12] Without controlling for schooling and/or black race, the negative association between white-collar employment and smoking would undoubtedly strengthen.

The high cigarette use among blue-collar compared to white-collar workers is consistent with earlier studies.[1–8] Many previous investigators have argued that blue-collar workers have less information on the adverse consequences of smoking. But health information is strongly associated with schooling,[45] and schooling was controlled for in Tables II through V. These results suggest that either characteristics of blue-collar work encourage smoking, or persons who smoke are more likely to select blue-collar work. The results do not support the assumption that blue-collar workers smoke more because they are less well-informed about smoking than white-collar workers, because schooling was removed as a confounder.

Characteristics of blue-collar employment that might encourage smoking include job strain, desires for risk, hazardous conditions, and boredom.

The high levels of cigarette use among blue-collar workers, especially those such as laborers and transportation operatives, are consistent with other findings on occupations, heart disease, and disability. Persons in jobs with little autonomy and great time pressure were found to have more symptoms of heart disease than others.[46–51] The job strain in low-paying blue-collar jobs could result in low self-efficacy, which, in turn, could lead to high cigarette use.[52–54]

Alternatively, the high cigarette use in some jobs may reflect workers' underlying desires for risk-taking, especially for men.[55] Meat cutters, truck drivers, sales workers who travel extensively,

police officers, sawing machine operators, construction workers, and mining workers are in especially dangerous jobs.[37] Men in these jobs smoke a lot, as the results in Table V suggest. But hazardous conditions themselves, such as exposure to carcinogens, would clearly elevate the risk of lung cancer of blue-collar over white-collar workers.[10] The SMRs in Table VII for men employed as roofers, miners, painters, welders, and plumbers are remarkably consistent with those[10] who attributed their high SMRs to exposure to carcinogens such as asbestos and polycyclic aromatic hydrocarbons.

Boredom may encourage smoking. If intellectual stimulation is lacking, some people may seek physiological stimulation.[56]

The desire for physiological stimulation and desire for risk have also been mentioned as reasons why some occupations are renowned for the alcohol use of incumbents. Transportation workers, seafarers, bartenders, waiters and waitresses, police officers, and firefighters have been found to drink much more and be much more likely to die of cirrhosis of the liver than people in other occupations.[35,57,58] Blue-collar workers, in general, have been found to drink more than white-collar workers.[59] These occupations, transportation workers through firefighters, also are high on these smoking and lung cancer lists. The blue-collar/white-collar disparity also is apparent in these lists.

In any case, high levels of cigarette use in blue-collar jobs is not a unique finding. Strong evidence for similar findings has been obtained in earlier studies.[1–8]

The blue-collar and white-collar dichotomy has a public policy implication. Persons who leave blue-collar jobs are more likely to apply for and receive Social Security disability benefits, as well as to retire earlier than white-collar employees.[60–63] This could be due to the stress and injury associated with these jobs. Alternatively, persons in low-paying jobs may find that Social Security benefits are sufficiently generous to warrant a feigned disability.[60] The results from this study suggest a third possibility: blue-collar workers may suffer more disability because they smoke more than white-collar workers.

Tables II through V also suggest another finding for men and women: the "no occupation" category is very high on both male lists, but very low on female lists. Two explanations can be offered for these findings. First, men who do not list an occupation could have long-standing and severe disabilities. The disabilities could be the result of smoking and keep them from working. Second, women who stay at home with children may be especially concerned about being a non-smoker.[9,16] Smoking can injure a fetus, and side smoke may injure a young child. Working for pay outside the home may encourage women to smoke.

The "no occupation" result for men has an implication for the unemployment-health debate. Some researchers contend that unemployment creates stress that, in turn, leads to health problems, especially in middle-aged men.[44,64,65] Our results suggest two alternative explanations: 1) the stress could manifest itself as increased cigarette use; or 2) the unemployed may simply smoke more than the employed, and it would be their smoking, not any added stress, that would result in their poor immune function.

There are some striking similarities between the rankings in earlier studies and those reported here. In their study of lung cancer rates among women, Menck et al.[11] also found cosmetologists, waitresses, and telephone/telegraph operators to be at excessively high risk. The Menck and Henderson[10] study of men also found roofers, photographers, miners, electricians, bartenders, plasterers, cooks, truck drivers, painters, plumbers, and welders to have an elevated risk of lung cancer.

Because of the high cigarette use of female managers, the blue-collar/white-collar dichotomy is not as evident among women. These results for women managers are consistent with those in the Sterling and Weinkam studies.[2,8] Unlike Sterling and Weinkam, but like Sorensen and Pechacek,[6] this study found female professionals to have the lowest levels of cigarette use.

Education is a well-known covariate of smoking.[45] Education, however, need not automatically be included as covariate in this study. Inclusion depends on which social science theory is assumed to explain the strong statistical association between edu-

cation and smoking. If the Human Capital theory is invoked, then education should be included as a covariate.[45,66] The Human Capital view is that education endows people with health knowledge, increases their chances of practicing healthy habits, and generally increases their efficiency in allocating resources to stay healthy. The Institutional view, on the other hand, holds that it is the person's job that results in health and health habits improving or deteriorating, and that education merely serves as a surrogate measure of job characteristics.[46] The Institutional view suggests that education should be excluded as a covariate, especially if measures of social and job pressures not to smoke at the job are *not* available in the data.

Because these two theories cannot be reconciled here, estimates were calculated that alternatively included and excluded education, although those presented in Tables II through V included schooling as a covariate. The results were surprisingly similar. The rank correlation coefficient for the two lists of specific jobs for females was 0.91; the rank correlation coefficient for males was 0.86. Education was not a statistically significant covariate in the Tobit regressions for women, but was for men. The univariate correlations between smoking and schooling were very strong and negative for both women and men. The blue-collar *versus* white-collar dichotomy for men was present whether or not schooling was entered as a covariate.

The greatest liability of all the rankings is that they only reflect observed patterns. We cannot conclude, for example, that the act of teaching lowers cigarette use or lung cancer rates. We can only conclude that persons who are teachers are likely to smoke little and have low chances of dying of lung cancer. The rankings, nevertheless, suggest that certain occupations, such as teaching at one extreme and truck driving and waitressing at the other, warrant additional investigation.

In conclusion, whereas criticisms can be lodged against the rankings in Tables II through VII, it bears mentioning that there does not appear to be any similar attempt in the literature to rank longest-held occupations by cigarette use, while simultaneously

adjusting for age, black race, schooling, attrition, and error correlations across geographic clusters. Moreover, this is the first study that attempts to rank occupations based on lung cancer deaths with death certificate data available in the COMS.

There are a number of valuable messages in these findings. 1) Medical researchers and physicians are quick to embrace psychology as a social science that can provide insights into who is prone to illness. The likelihood that sociology or economics could also provide insights seems remote. The fact that clear patterns emerge between occupations, on the one hand, and smoking and lung cancer, on the other, strengthens the view that sociology and economics can provide insights. The characteristics of people employed in various occupations (gender, schooling) and the characteristics of those occupations (wages) have received considerable research attention from sociologists and economics. 2) The "job strain" model developed by the physician/sociologist R.A. Karasek[46,47] is useful in understanding which occupations are more or less likely to encourage people to smoke. 3) Economic theories surrounding job choice[55] across risky and safe jobs as well as theories of human capital[45] also are useful.

The research also has implications for interventions. 1) To the extent that "job strain" encourages smoking, job interventions that provide greater autonomy, greater decision-making authority regarding the production process, greater job security, higher wages, and better working conditions might be appropriate. 2) If more attention was paid by management to safety and health than is the case currently, workers might not be so fatalistic and may stop smoking. 3) Finally, many economists have suggested that improvements in economy-wide investments in education would greatly reduce smoking. Our findings suggest that education as an intervention may not have as strong an effect as the economists suggest if the structure of occupations remains unchanged.

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